Grey Ballard

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Education

Ph.D. in Computer Science   Fall 2008 – Summer 2013

University of California Berkeley, with a Designated Emphasis in Computational Science and Engineering

Advisor: James Demmel, Thesis: Avoiding Communication in Dense Linear Algebra

M.A. in Mathematics   Fall 2006 – Spring 2008

Wake Forest University, Advisor: John Baxley

B.S. in Mathematics and Computer Science   Fall 2002 – Spring 2006

Wake Forest University, *summa cum laude* with honors in mathematics and honors in computer science

Honors and Awards

ACM Doctoral Dissertation Award - Honorable Mention   2014

Presented annually to the authors of the best doctoral dissertations in computer science and engineering

Harry S. Truman Fellowship in National Security Science and Engineering   2013

Three year fellowship at Sandia National Laboratories providing the opportunity for recipients
to pursue independent research in the national interest

IPDPS Best Paper Award in Algorithms Track   2013

Awarded by the program committee, with coauthors Dulceneia Becker, James Demmel, Jack Dongarra, Alex
Druinsky, Inon Peled, Oded Schwartz, Sivan Toledo, and Ichitaro Yamazaki

C.V. Ramamoorthy Distinguished Research Award   2012

Awarded by the UC Berkeley EECS Student Awards Committee, based on outstanding contributions
by a computer science graduate student to a new research area in computer science and engineering

SIAM SIAG/Linear Algebra Prize   2012

Awarded triennially by prize committee, with co-authors James Demmel, Olga Holtz, and Oded Schwartz

SPAA Best Paper Award   2011

Awarded by program committee, with co-authors James Demmel, Olga Holtz, and Oded Schwartz

William C. and Ruth N. Archie Award   2006

Awarded to outstanding senior demonstrating commitment to liberal learning, scholarship, and ideals of WFU

John Y. Phillips Prize in Mathematics   2006

Awarded by WFU mathematics department to the outstanding graduating senior

Edwin G. Wilson Male Student Athlete of the Year   2006

Awarded by WFU athletic department to the athlete who displays excellence in both academics and athletics

Professional Working Experience

Truman Fellow   Summer 2013 – present

Sandia National Laboratories, Livermore CA

Graduate Student Researcher   Fall 2008 – Spring 2013

UC Berkeley computer science department

Graduate Student Intern   Summer 2010 – Summer 2012

Sandia National Laboratories, Livermore CA, Mentor: Tamara Kolda

Graduate Student Instructor   Spring 2011, Fall 2012

UC Berkeley computer science department

Reader   Fall 2011

UC Berkeley mathematics department

Teaching Assistant   Summer 2006 – Spring 2008

Wake Forest University mathematics department

Publications

Journal Papers

1. Avoiding Communication in Successive Band Reduction. Grey Ballard, James Demmel, and Nicholas Knight. *ACM Transactions on Parallel Computing*. Volume 1, Issue 2, pp. 11:1-11:37. 2015.

2. Communication-Avoiding Symmetric-Indefinite Factorization. Grey Ballard, Dulceneia Becker, James Demmel, Jack Dongarra, Alex Druinsky, Inon Peled, Oded Schwartz, Sivan Toledo and Ichitaro Yamazaki. *SIAM Journal on Matrix Analysis and Applications*. Volume 35, Issue 4, pp. 1364-1406. 2014.

3. Communication Lower Bounds and Optimal Algorithms for Numerical Linear Algebra. Grey Ballard, Erin Carson, James Demmel, Mark Hoemmen, Nicholas Knight, Oded Schwartz. *Acta Numerica*. Volume 23, pp. 1-155. 2014.

4. Communication Costs of Strassen's Matrix Multiplication. Grey Ballard, James Demmel, Olga Holtz, and Oded Schwartz. *Communications of the ACM*. Volume 57, Number 2, pp. 107-113. 2014.

5. Asymptotic Behavior of the Eigenvalues of Toeplitz Integral Operators Associated with the Hankel Transform. Grey Ballard and John Baxley. *Dynamic Systems and Applications*, Volume 23, pp. 505-530, 2014.

6. Graph Expansion and Communication Costs of Fast Matrix Multiplication. Grey Ballard, James Demmel, Olga Holtz, and Oded Schwartz. *Journal of the ACM*. Volume 59, Issue 6, Article 32. 2012.

7. Minimizing Communication in Linear Algebra. Grey Ballard, James Demmel, Olga Holtz, and Oded Schwartz. *SIAM Journal on Matrix Analysis and Applications*, Volume 32, Issue 3, pp. 866-901. 2011.

8. Communication-optimal parallel and sequential Cholesky decomposition. Grey Ballard, James Demmel, Olga Holtz, and Oded Schwartz. *SIAM Journal on Scientific Computing*. Volume 32, Issue 6, pp. 3495-3523. 2010.

9. Existence of Solutions for a Class of Singular Nonlinear Third Order Autonomous Boundary Value Problems. Grey Ballard and John Baxley. *Communications in Applied Analysis*. Volume 15, No. 2-4, pp. 195-202. 2011.

10. The Friedrichs extension of certain singular differential operators. Grey Ballard and John Baxley. *Electronic Journal of Qualitative Theory of Differential Equations*. Special Edition I, No. 5, pp. 1-11. 2009.

11. Qualitative behavior and computation of multiple solutions of nonlinear boundary value problems. Grey Ballard, John Baxley, and Nisrine Libbus. *Communications on Pure and Applied Analysis*. Volume 5, No. 2, pg. 251-259. 2006.

Conference Proceedings

1. Brief Announcement: Hypergraph Partitioning for Parallel Sparse Matrix-Matrix Multiplication. Grey Ballard, Alex Druinsky, Nicholas Knight, and Oded Schwartz. *Proceedings of the 27th Annual ACM Symposium on Parallelism in Algorithms and Architectures*. To appear. 2015.

2. A Framework for Practical Parallel Fast Matrix Multiplication. Austin Benson and Grey Ballard. *Proceedings of the 20th ACM Symposium on Principles and Practice of Parallel Programming*. ACM, New York, NY, USA, 42-53. 2015.

3. Reconstructing Householder Vectors from TSQR. Grey Ballard, James Demmel, Laura Grigori, Mathias Jacquelin, Hong Diep Nguyen, and Edgar Solomonik. *Proceedings of the 28th IEEE International Parallel and Distributed Processing Symposium*. IEEE Computer Society, Washington, DC, USA, 1159-1170. 2014.

4. Communication Optimal Parallel Multiplication of Sparse Random Matrices. Grey Ballard, Aydin Buluc, James Demmel, Laura Grigori, Benjamin Lipshitz, Oded Schwartz and Sivan Toledo. *Proceedings of the 25th Annual ACM Symposium on Parallelism in Algorithms and Architectures.* ACM, New York, NY, USA, 222-231. 2013.

5. Communication Efficient Gaussian Elimination with Partial Pivoting using a Shape Morphing Data Layout. Grey Ballard, James Demmel, Benjamin Lipshitz, Oded Schwartz and Sivan Toledo. *Proceedings of the 25th Annual ACM Symposium on Parallelism in Algorithms and Architectures.* ACM, New York, NY, USA, 232-240. 2013.

6. Implementing a Blocked Aasen's Algorithm with a Dynamic Scheduler on Multicore Architectures. Grey Ballard, Dulceneia Becker, James Demmel, Jack Dongarra, Alex Druinsky, Inon Peled, Oded Schwartz, Sivan Toledo and Ichitaro Yamazaki. *Proceedings of the 27th IEEE International Parallel and Distributed Processing Symposium.* IEEE Computer Society, Washington, DC, USA, 1530-2075. 2013.

7. Communication-Avoiding Parallel Strassen: Implementation and Performance. Benjamin Lipshitz, Grey Ballard, Oded Schwartz, James Demmel. *Proceedings of the International Conference on High Performance Computing, Networking, Storage and Analysis.* IEEE Computer Society Press, Los Alamitos, CA, USA, 101:1–101:11. 2012.

8. Communication-Optimal Parallel Algorithm for Strassen's Matrix Multiplication. Grey Ballard, James Demmel, Olga Holtz, Benjamin Lipshitz, Oded Schwartz. *Proceedings of the 24th Annual ACM Symposium on Parallelism in Algorithms and Architectures.* ACM, New York, NY, USA, 193-204. 2012.

9. Brief Announcement: Strong Scaling of Matrix Multiplication Algorithms and Memory-Independent Communication Lower Bounds. Grey Ballard, James Demmel, Olga Holtz, Benjamin Lipshitz, Oded Schwartz. *Proceedings of the 24th Annual ACM Symposium on Parallelism in Algorithms and Architectures.* ACM, New York, NY, USA, 77-79. 2012.

10. Graph Expansion Analysis for Communication Costs of Fast Rectangular Matrix Multiplication. Grey Ballard, James Demmel, Olga Holtz, Benjamin Lipshitz, Oded Schwartz. *Proceedings of the 1st Mediterranean Conference on Algorithms.* Springer, Berlin, Germany. Lecture Notes in Computer Science, Vol. 7659, 13–36. 2012.

11. Communication Avoiding Successive Band Reduction. Grey Ballard, James Demmel, Nicholas Knight. *Proceedings of the 17th ACM Symposium on Principles and Practice of Parallel Programming.* ACM, New York, NY, USA, 35-44. 2012.

12. Graph Expansion and Communication Costs of Fast Matrix Multiplication. Grey Ballard, James Demmel, Olga Holtz, and Oded Schwartz. *Proceedings of the 23rd Annual ACM Symposium on Parallelism in Algorithms and Architectures.* ACM, New York, NY, USA, 1-12. 2011.

13. Brief Announcement: Communication Bounds for Heterogeneous Architectures. Grey Ballard, James Demmel, and Andrew Gearhart. *Proceedings of the 23rd Annual ACM Symposium on Parallelism in Algorithms and Architectures.* ACM, New York, NY, USA, 257-258. 2011.

14. Communication-Avoiding QR Decomposition for GPUs. Michael Anderson, Grey Ballard, James Demmel, and Kurt Keutzer. *Proceedings of the 25th IEEE International Parallel and Distributed Processing Symposium.* IEEE Computer Society, Washington, DC, USA, 48-58. 2011.

15. Efficiently Computing Tensor Eigenvalues on a GPU. Grey Ballard, Tamara Kolda, and Todd Plantenga. *Proceedings of the 25th IEEE International Parallel and Distributed Processing Symposium Workshops and PhD Forum.* IEEE Computer Society, Washington, DC, USA, 1340-1348. 2011.

16. Communication-optimal parallel and sequential Cholesky decomposition. Grey Ballard, James Demmel, Olga Holtz and Oded Schwartz. *Proceedings of the 22nd Symposium on Parallelism in Algorithms and Architectures.* ACM, New York, NY, USA, 245-252. 2009.

Student Journals

1. Qualitative behavior and computation of multiple solutions of singular nonlinear boundary value problems. Grey Ballard and John Baxley. *Involve, a Journal of Mathematics*. Volume 1, No. 1, pp. 21-31. 2008.
2. Modeling protein dependency networks using CoCoA. Grey Ballard. *ACM Crossroads*. Issue 13.1. 2006.

Technical Reports

1. Contention Bounds for Combinations of Computation Graphs and Network Topologies. Grey Ballard, James Demmel, Andrew Gearhart, Benjamin Lipshitz, Oded Schwartz and Sivan Toledo. UC Berkeley Technical Report EECS-2014-147. 2014.
2. Sequential Communication Bounds for Fast Linear Algebra. Grey Ballard, James Demmel, Olga Holtz and Oded Schwartz. UC Berkeley Technical Report EECS-2012-36. 2012.
3. Minimizing Communication for Eigenproblems and the Singular Value Decomposition. Grey Ballard, James Demmel, Ioana Dumitriu. UC Berkeley Technical Report EECS-2011-14. 2011.

Theses

1. Avoiding Communication in Dense Linear Algebra. Grey Ballard. PhD Thesis. University of California Berkeley. 2013.
2. Asymptotic behavior of the eigenvalues of Toeplitz integral operators associated with the Hankel transform. Grey Ballard. Master's Thesis. Wake Forest University. 2008.

Talks

- Reducing Communication Costs for Sparse Matrix Multiplication in Algebraic Multigrid. Presented at SIAM Conference on Computational Science and Engineering in March 2015 in Salt Lake City, UT and at Copper Mountain Conference on Multigrid Methods in March 2015 in Copper Mountain, CO.
- Reducing Computation and Communication in Scientific Computing. Presented at Wake Forest University in January 2015 in Winston-Salem, NC, at the College of William & Mary in February 2015 in Williamsburg, VA, and at Georgia Tech in February 2015 in Atlanta, GA.
- How Practical is Fast Matrix Multiplication?. Presented at the Matrix Computations Seminar (UC Berkeley) in October 2014 in Berkeley, CA and at the Simons Institute in December 2014 in Berkeley, CA.
- Communication-Avoiding Algorithms and Fast Matrix Multiplication. Presented at Microsoft Research in September 2014 in Redmond, WA.
- Algorithms with Provably Minimal Communication: Algorithmic Improvements for QR Decomposition. Presented at Duke University in July 2014 in Durham, NC.
- Avoiding Communication in Linear Algebra. Presented at Microsoft Research Faculty Summit in July 2014 in Redmond, WA.
- Reconstructing Householder Vectors from TSQR. Presented at SIAM Conference on Parallel Processing for Scientific Computing in February 2014 in Portland, OR, at the Matrix Computations Seminar (UC Berkeley) in February 2014 in Berkeley, CA, at the University of Texas in March 2014 in Austin, TX, at International Parallel and Distributed Processing Symposium in May 2014 in Phoenix, AZ, at Householder Symposium XIX in June 2014 in Spa, Belgium, and at the Linear Algebra and Optimization Seminar (Stanford) in January 2015 in Stanford, CA.
- Searching for Fast Matrix Multiplication Algorithms. Presented at the Dean Seminar (Sandia National Labs) in November 2013 in Livermore, CA.
- Communication-Optimal Parallel Algorithm for Strassen's Matrix Multiplication. Presented at the Simons Institute in October 2013 in Berkeley, CA.

- Communication Efficient Gaussian Elimination with Partial Pivoting using a Shape Morphing Data Layout. Presented at SPAA in July 2013 in Montreal, Canada.
- Communication-Avoiding Algorithms and Autotuning. Presented at the Par Lab End-of-Project Celebration in May 2013 in Berkeley, CA.
- Avoiding Communication in Linear Algebra. Presented at the University of Virginia in April 2013 in Charlottesville, VA.
- Avoiding Communication in Dense Linear Algebra. Dissertation talk presented at UC Berkeley in April 2013 in Berkeley, CA.
- Avoiding Communication in Parallel Bidiagonalization of Band Matrices. Presented at SIAM Conference on Computational Science and Engineering in March 2013 in Boston, MA.
- Reducing Computation and Communication in Scientific Computing. Presented at Sandia National Laboratories in January 2013 in Livermore, CA and Albuquerque, NM.
- Avoiding Communication in Linear Algebra. Presented at Lawrence Berkeley National Laboratory in January 2013 in Berkeley, CA.
- Communication-Avoiding Parallel Strassen: Implementation and Performance. Presented at SC in November 2012 in Salt Lake City, UT and Bay Area Scientific Computing Day in December 2012 in Palo Alto, CA.
- Communication-Optimal Parallel Algorithm for Strassen's Matrix Multiplication. Presented at Sandia National Labs in August 2012 in Livermore, CA.
- Communication-Avoiding Successive Band Reduction. Presented at Householder Symposium XVIII on Numerical Linear Algebra in June 2011 in Tahoe City, CA and PPoPP in February 2012 in New Orleans, LA.
- Communication-Avoiding Nonsymmetric Eigensolver using Spectral Divide & Conquer. Presented at SIAM Conference on Parallel Processing for Scientific Computing in February 2012 in Savannah, GA and at IWASEP 9 in June 2012 in Napa, CA.
- Lower Bounds for Communication in Linear Algebra. Presented at Workshop on Synchronization-reducing and Communication-reducing Algorithms and Programming Models for Large-scale Simulations in January 2012 in Providence, RI.
- Graph Expansion and Communication Costs of Fast Matrix Multiplication. Presented at SPAA in June 2011 in San Jose, CA.
- Communication Bounds for Heterogeneous Architectures. Presented at SPAA in June 2011 in San Jose, CA.
- Efficiently Computing Tensor Eigenvalues on a GPU. Presented at at Sandia National Labs Student Intern Symposium in August 2010 in Livermore, CA and PDSEC Workshop in conjunction with IPDPS in May 2011 in Anchorage, AK.
- Communication-Avoiding Dense Linear Algebra. Presented at CScaDS Autotuning Workshop in August 2010 in Snowbird, UT.
- Mapping Communication-Avoiding QR Decomposition to Various Architectures. Presented at SIAM Annual Meeting in July 2010 in Pittsburgh, PA.
- Communication Bounds for Sequential and Parallel Eigenvalue Problems. Presented at SIAM Conference on Parallel Processing for Scientific Computing in February 2010 in Seattle, WA and at AMS Western Section Meeting and at Sandia National Labs in April 2010 in Albuquerque, NM.
- Minimizing Communication in Linear Algebra. Presented at Par Lab Summer Retreat in June 2009 in Santa Cruz, CA and at SIAM Workshop on Combinatorial and Scientific Computing in October 2009 in Monterey, CA.
- Communication-Optimal Parallel and Sequential Cholesky Decomposition. Presented at SPAA in August 2009 in Calgary, Canada.

Teaching Experience

Graduate Student Instructor UC Berkeley

CS 170: Efficient Algorithms and Intractable Problems with Satish Rao, Fall 2012

CS 267: Applications of Parallel Computers with James Demmel and Katherine Yelick, Spring 2011

Reader UC Berkeley

Math 221: Matrix Computations/Numerical Linear Algebra with James Demmel, Fall 2011

Teaching Assistant Wake Forest University

Math 109: Probability and Statistics with Julie Connolly, Spring 2008

Math 121: Linear Algebra with Jim Kuzmanovich, Fall 2007

Math 112: Calculus II with Miaohua Jiang, Spring 2007

Math 113: Vector Calculus with Stephen Robinson, Fall 2006

Math 112: Calculus II with Hugh Howards, Summer 2006

Mentoring Experience

Graduate Student Intern Sandia National Laboratories

Austin Benson (Stanford University), Summer 2014

Professional Activities

Program Committee 2015

ACM SIGPLAN Principles and Practice of Parallel Programming (PPoPP)

Program Committee 2015

ACM Symposium on Parallelism in Algorithms and Architectures (SPAA)

Program Committee 2014

IEEE International Parallel and Distribution Processing Symposium (IPDPS)

Program Committee 2014

IEEE International Workshop on Parallel and Distributed Scientific and Engineering Computing (PDSEC)

Program Committee 2011-2014

Euromicro International Conference on Parallel, Distributed, and Network-Based Processing (PDP)

Workshop Organizer 2014

Workshop on Fast Matrix Multiplication, 12 attendees, Berkeley, CA

External Reviewer

SIAM Journal on Matrix Analysis and Applications (SIMAX)

SIAM Journal on Scientific Computing (SISC)

ACM Transactions on Mathematical Software (TOMS)

ACM Transactions on Parallel Computing (TOPC)

Parallel Computing

Algorithmica

ACM Symposium on Parallelism in Algorithms and Architectures (SPAA)

International European Conference on Parallel Processing (Euro-Par)

ACM Symposium on Principles of Programming Languages (POPL)

European Symposium on Algorithms (ESA)

Symposium on Theoretical Aspects of Computer Science (STACS)

International Symposium on Algorithms and Computation (ISAAC)

IEEE Transactions on Mobile Computing (TOMC)

AMS Mathematical Reviews

Book Reviewer 2015

SIAM Review (SIREV)

Member

SIAM, ACM, AMS, IEEE